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THE DEVELOPMENT OF THE BUILDING MATERIALS AND CONSTRUCTION INDUSTRIES IN AFRICA BASED ON INDIAN EXPERIENCES (REPORT ON TRAINING PROGRAMME ORGANIZED BY ECA IN INDIA FOR AFRICAN EXPERTS)

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PREFACE

The secretariat of the Economic Commission for Africa initiated, in 1978, a programme for the development of the building materials and construction industries in Africa. The primary objective of the programme is to assist the African countries to achieve an increasing degree of self-sufficiency in these industries speedily.

One of the major activities of the regional programme concerns seeking ways and means of encouraging the practical sharing of experiences in the production and utilization of essential building materials between African specialists and their counterparts from developing countries of other regions. It was in this connexion that in 1981 ECA organized, in collaboration with the Government of India, two training programmes for African experts on the building materials and construction industries drawn from sixteen countries.

This document contains the findings of the training programmes, which included study tours, in-plant training and a technical workshop, and also discusses the relevance of Indian experiences in the field of building materials and construction to the situation in African countries. The document is being published by ECA with the primary objective of informing the governments of member States of the Commission about the progress that India has made in solving some of the major problems faced by the building materials and construction industries in that country. It is the hope of ECA that governments would draw valuable lessons from those experiences in planning suitable programmes and projects that will promote the achievement of self-sufficiency in the building materials and construction industries, both at the national and regional levels.

The secretariat of ECA wishes to express its appreciation to the Government of India for its financial and technical support which made it possible to organize the training programmes in India for the African experts.

ABBREVIATIONS

Indian organizations

CBRI	Central Building Research Institute
CRI	Cement Research Institute of India
CPWD	Central Public Works Department
CSIR	Council of Scientific and Industrial Research
DDA	Delhi Development Authority
FRI	Forest Research Institute
HPL	Hindustan Prefab Limited
HUDCO	Housing and Urban Development Corporation
IPIRI	Indian Plywood Industries Research Institute
KVIC	Khadi and Village Industries Commission
NBCC	National Buildings Construction Corporation
NBO	National Buildings Organization
NRDC	National Research Development Corporation
SERC	Structural Engineering Research Centre

International organizations

UNECA	United Nations Economic Commission for Africa
OAU	Organization of African Unity
UNCHS	United Nations Centre for Human Settlements
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNIDO	United Nations Industrial Development Organization

INTRODUCTION

The Governments of the States members of the United Nations Economic Commission for Africa have for long been concerned about the high cost of construction in their countries which, in part, has had a negative impact on their ability to implement planned programmes for the construction of civil engineering structures, administrative buildings, housing schemes, schools, clinics and other social buildings. Convinced that African countries have the potential to minimize the rising cost of construction and control its rate of growth through a more concerted and rational use of indigenous human and natural resources, various meetings and conferences of ECA organs have, in the past, adopted many resolutions and recommendations on the need for improvement in the construction and building materials industries sector and urged the secretariat of ECA to initiate a development programme, in collaboration with the appropriate United Nations bodies, with the aim of assisting African countries to achieve self-sufficiency in the sector by the year 2000. This concern was reiterated by the Economic Summit of the Heads of State and Government of the member countries of the OAU held in Lagos in April 1980.

In accordance with the above directives, ECA, in consultation with the United Nations Industrial Development Organization (UNIDO), the United Nations Environment Programme (UNEP) and the Organization of African Unity prepared an integrated development programme for the building materials and construction industries sector which began to be implemented in 1978. In the implementation of the programme, four major areas which correspond to priorities identified by the experts of African countries at meetings organized by ECA have been emphasized. These areas are: government policies and organizational support; production of building materials and the development of related raw materials and other inputs; research and technology development including information services; and construction services development and management.

Attention has also been directed at the benefits that could be derived from TCDC 1/ activities with respect to the enhancement of the achievement of the desired goal of self sufficiency in the building materials and construction industries sector as early as possible. Thus efforts have been made to encourage the practical sharing of experience between African experts and their counterparts from developing countries of other regions in the production of essential building materials and their utilization in construction, as well as the general promotion of the development of the sector. It is worth noting in this context that some developing countries in other regions that have experienced difficulties similar to those being faced by African countries in this sector have succedded in adopting new policies and innovative strategies for the decentralization and diversification of building materials production, organization and development of inexpensive technologies and the rational use of manpower. This is true, for example, of the design, establishment and operation of large, medium and small-scale building materials units tailored to the needs in particular local situations.

1/ TCDC: Technical Co-operation among Developing Countries

It is also true of the various institutional machineries set up to organize the required activities in a co-ordinated manner.

Within the framework of the above considerations, ECA, in collaboration with the Government of India, organized a study tour followed by a technical workshop in India for a team of 12 African experts on the building materials and construction industries drawn from Burundi, Congo, Ethiopia, Ghana, Guinea, Madagascar, Nigeria, Sudan, Tunisia, the United Republic of Cameroon and the United Republic of Tanzania, during the period 30 April to 15 June 1981. The purpose of the programme was to provide an opportunity for the experts, who were mainly high-level technicians from the ministries of planning, industry, works, housing, and also from research and promotional organizations, to acquire a first-hand experience of, and to familiarize themselves with the progress that India had made in the building materials and construction industries sector by making use of all kinds of resources available locally. The programme was also designed to assist the experts in identifying specific ways in which African countries could take advantage of the experiences of India, giving due attention to the specific nature of available resources and needs in individual countries.

An in-plant training programme was also organized from 21 October to 27 November 1981 for a second team of 6 African experts from Angola, Central African Republic, the Gambia, the Ivory Coast, Togo and the United Republic of Tanzania who were mainly technicians involved directly in the production of building materials and with building construction activities. The purpose of this activity was to enable the experts to study, in detail, specific aspects of the building industry in India and to gain additional experience which could be useful in promoting the adoption of production systems and technologies that are appropriate to conditions in their countries.

This document gives a synthesis of the findings of the study tour and workshop as well as the in-plant training programme, based on the report of the workshop 2/ and the experiences gained by the African experts who participated in the training programmes as spelt out in the reports they submitted to ECA at the end of their programmes. Against the background of the existing situation in many African countries regarding the building materials and construction industries and the efforts that are being made at both the national and regional levels to bring about improvements, the document highlights the progress that has been made in India towards achieving self-sufficiency in various aspects of the building industry. The relevance of the Indian experiences to the situation in African countries is then discussed.

The document also gives recommendations on actions that need to be taken at the national and regional levels as a follow-up to the above training programmes in order that the full benefits of the programmes could be realized in the countries of the African region.

Finally, the document highlights the role of the Economic Commission for Africa and other United Nations organizations in promoting co-operation between African countries and India in the field of building materials and construction.

This document is being published by ECA with the primary objective of informing the Governments of member States of the Commission about some of the progress that India has made in solving the problems facing the building materials and construction industries in that country, with the hope that it will stimulate the Governments to examine India's experiences more closely to determine their applicability to the countries of the African region.

2/ Report on workshop on the development of the building materials and construction industries in Africa based on Indian experiences, ST/ECA/HUS/3, October 1981.

SUMMARY

The success achieved so far by India in the field of building materials and construction stems, in part, from the considerable importance that the Government of India attaches to science and technology as an instrument for achieving self-reliance in the different facets of national economic and social development. The development and application of small to medium-scale, non-capital intensive technologies that conform to the prevailing socio-economic and technical conditions and respond to the Government's policy for decentralization and dispersal of industries into rural and backward areas has received emphasis in the past.

Institutional support

The Government of India has set up various institutional mechanisms in pursuit of the objectives of its policies with regard to the development of building materials and construction industries. These include institutions that carry out research, establish pilot plants and projects for demonstrating the research findings, and assist in the commercial application of research findings; institutions engaged in the transfer of technology from research and development institutions to potential users in industry; and institutions that provide finance for setting up building materials plants and for implementing housing and urban development programmes. The Government has also promoted the formation of building materials manufacturers associations which provide the manufacturers an organized forum for dealing with, and finding solutions to the problems faced by the industry.

Production of building materials

The high priority accorded to the local production of building materials from available raw material resources has underpinned the success achieved in reducing shortages in the supply of building materials for building projects in India. In addition to upgrading conventional materials like cement, clay brick, steel and timber, and developing techniques for their efficient use in construction, efforts have also been made to promote the development of other types of building materials which could serve, in some cases, as partial or complete substitutes for the conventional materials. For example, the production of lime, pozzolana, rice-husk ash masonry cement (from lime and rice-husk ash), pressed stabilized soil bricks, clay roofing tiles, asphaltic roofing sheets, and other materials based on industrial and agricultural wastes, has received increasing attention.

India has also made advances in the development, locally, of suitable technologies and also in the manufacture of machines, equipment and tools, for the production of building materials used by the building industry. For example, technologies have been developed for the production of burnt brick, lime, lime-pozzolana, rice-husk ash masonry cement, ordinary portland cement (in mini-cement plants), stone-ware pipes, etc.

Research and technology development

The existence of local capabilities for developing suitable technologies for use in the buildin materials and construction sector is necessary for achieving the desired growth in this sector. The Council of Scientific and Industrial Research (CSIR) which plays an important role in the formulation of national research policies in India, has the Prime Minister as its President. Research and development programmes therefore enjoy the full support of top Government policy makers. The autonomy given to public research institutions in their operations and the level of resources put at their disposal have

helped greatly in enhancing their effectiveness. The building materials manufacturing industry itself also assists in the provision of financial resources for the development of research capabilities in India. The Cement Research Institute of India (CRI) at Ballabgarh and the Indian Plywood Industries Research Institute (IPIRI) at Bangalore are examples of co-operative financing of research institutions by the Government, the industry and the Council of Scientific and Industrial Research.

The National Research Development Corporation (NRDC) ensures the co-ordinated follow-up of the research and development work carried out by national research institutes in the field of science and technology, and helps to achieve the speedy application of newly developed processes and techniques in pilot trials or commercial ventures. NRDC, among other activities, sets up demonstration projects, sometimes in collaboration with financial institutions, service organizations, voluntary organizations and others interested in the promotion of indigenous technologies.

The National Buildings Organization (NBO), which is under the Ministry of Works and Housing, deals with the specific problems of housing and related matters. It ensures the transfer of technology and research findings from the research institutes to the building materials and construction sector with a view to achieving cost reduction in housing and building. The activities undertaken by NBO include erection of demonstration houses, setting up of pilot/demonstration plants for building materials production, organization of training courses, seminars, symposia, exhibitions and film shows.

Construction services

In the field of development and management of construction services also, India has made substantial progress. Almost all construction projects are undertaken by local construction companies both in the public and private sectors. The Central Public Works Department (CPWD), which is the Central Government department responsible for the implementation of all its construction projects, undertakes the planning, design and engagement of contractors for the execution of such projects.

The National Buildings Construction Corporation (NBCC) is entrusted with the execution of public constructions. It supervises projects on behalf of clients, provides consultancy services in manpower planning, quality control and technical auditing of construction works, and undertakes turn-key services including project planning, design and implementation. It also promotes the strengthening of the capabilities of indigenous construction companies.

The Housing and Urban Development Corporation (HUDCO), a financing institution set up by the Government of India, assists with finance for the execution of some construction projects. For example, it grants loans to State Housing Boards for the construction of housing estates. This helps not only in providing houses for various income earners, but also provides opportunities for some building contractors to increase their wealth of experience in project execution.

Relevance of Indian experiences to African countries

India has achieved significant successes in containing the problems faced by the building construction industry. This has been the result of various measures taken by the Government pertaining to the different phases of the building process, from the production of building materials through to the management of building construction services. Appropriate support institutions have also been created.

The philosophy upon which the building materials and construction industries in India have been developed, that is, maximum dependence on, and utilization of locally available resources, is akin to the philosophy of self-reliance embodied in the Lagos Plan of Action, which is the blueprint for Africa's economic and social development during the next twenty years. Besides, India shares many common characteristics with the majority of countries in the African region. They are all developing countries striving to improve the existing economic and social conditions with limited financial resources; they have, in general, a large unskilled labour force and possess abundant raw material resources that could be exploited for building materials production. The experience gained by India could therefore provide a useful input into the efforts of African Governments to achieve improvements in the building materials and con truction industries.

The application of the experiences of India in African countries should be considered in the light of the specific conditions prevailing in those countries to ensure that maximum benefit is derived from the technologies that are transferred to the countries. For example, the labour intensive techniques that have been used successfully in India to produce the bulk of such materials as burnt bricks, clay roofing tiles and lime would have to be studied further to arrive at suitable labour-capital ratios, since labour costs in the majority of African countries are higher than those pertaining in India.

The promotional measures that have been adopted in India for increasing the production and use of indigenous building materials should all engage the attention of African governments. These include, the establishment of pilot and demonstration projects, provi ion of incentives to building materials producers through the supply of essential inputs (like coal), assistance in the mobilization of finance for setting up building materials plants, research and technological back-up services, organization of educational and training courses, formulation and application of appropriate building materials standards, as well as building regulations, etc.

African Governments need to give renewed attention to the development of an effective, locally-relevant research and development base. The co-ordination of scientific and technological research at the national level, and the promotion of the adoption of newly developed processes and techniques through institutions like the Council of Scientific and Industrial Research, the National Research Development Corporation and the National Buildings Organization of India should be accorded priority. African Governments should also explore the possibilities of encouraging the industrial sector itself to assist in financing research and development activities and also in making use of the research findings.

Building and building materials research institutes in Africa should establish channels of information exchange with their counterparts in India. This will assist in determining which processes or techniques developed in India could be applied directly and those that could be adopted with suitable modifications for application in individual countries of the African region.

Follow-up actions

The African experts who participated in the training programmes organized in India in 1981 by the Economic Commission for Africa called upon the secretariat of the Commission to take the necessary measures to ensure that the experiences gained by them were disseminated widely in the African countries through the organization of regional/subregional/national seminars and also through the publication of technical documents. ECA was also called upon to organize similar training programmes in African countries and also in countries outside the African region.

Another practical follow-up action which ECA was called upon by the African experts to undertake is the establishment of pilot-cum-demonstration plants, in collaboration with interested African countries, for the production of materials, for example, lime, lime-pozzolana, cement (on small-scale) and roofing sheets from agricultural wastes, based on simple technologies developed in India.

The African Governments themselves should ensure that maximum use is made, at the national level, of the opportunities for making greater use of indigenous resources for improving the condition and performance of the building materials and construction sector that have been brought into focus by the training programmes organized by ECA in India. They should, inter alia, seek avenues for establishing operational linkages with India and other developing countries and international organizations with a view to developing bilateral and multilateral technical co-operation in the field of building materials and construction industries.

I. THE BUILDING MATERIALS AND CONSTRUCTION INDUSTRIES IN AFRICA

1. Existing situation

The building materials and construction industries constitute an important factor of national economic growth because of their linkages with a number of national social and economic activities - more specifically human settlements - and their potential for employment generation on a massive scale. Although these industries are of primary importance to the development of Africa, their performance and growth have not matched the needs in the countries of the region.

The building materials industry, in general, produces a limited range of materials at such a high price that the majority of the population is unable to afford them. It has not been able to meet all the needs of the construction industry and, in general, suffers from the following constraints: dependence on imported raw materials; use of inappropriate technology; inability to improve and commercialize traditional building materials; and low capacity utilization. 3/ The majority of the existing building materials plants have obsolete machinery and equipment and face difficulties in obtaining spare parts to undertake the necessary maintenance and repairs. The concentration of plants in a few locations coupled with poor transportation networks sometimes leads to acute shortages of essential building materials in some parts of the countries. At the subregional level, there is an unbalanced pattern of production and consumption. Intra-African trade is so limited that even those commodities that African countries have traditionally exported, such as wood, do not get to other African nations.

The construction industry which, next to agriculture is the most important sector of economic activities in Africa, is affected by: heavy dependence on foreign contractors; lack of skilled manpower; shortage of capital and equipment; irregular supply of building materials; and use of inappropriate technologies. A basic drawback which prevails also in the construction industry is the general lack of efficient managers with capacity to plan and organize site operations. This situation exacerbates the deficiencies regarding building materials, labour and equipment. Lack of co-ordinated planning of construction programmes at the national level prevents any realistic organization of the production and/or importation of essential building materials which, in turn, affects the smooth execution of construction projects.

Construction activities in most African countries, by concentrating in urban centres, neglect the needs in the rural areas. The urban sector receives the main attention of the authorities with the result that the improvement of building materials and techniques as a means of upgrading the socio-economic conditions in the rural areas is not given the required emphasis.

The prevailing administrative procedures in most African countries also constitute a bottleneck to the development of the local building materials industry. Many existing building codes, for example, lay emphasis on the use of cement and cement-based products and prohibit the use of materials like alternative binders, burnt bricks, soil-cement, secondary species of wood and others whose utilization the countries are now taking measures to promote.

3/ Building materials and construction industries development programme E/CN.14/HUS/29, September 1978.

2. Prospects for the development of the industries

African countries are not poor in natural resources which, when developed using technologies appropriate to local conditions, would help greatly to resolve the present dilemma facing the construction industry on account of shortage of essential building materials. Even though the raw materials and other factor inputs are not evenly distributed in the various countries of the region, it is clear that within the framework of the principle of collective self reliance which has been embraced by the Governments, the problems of the building materials industry could be solved through a unified approach covering not only national potentials but the options open at the subregional level to groups of countries prepared to undertake joint actions on specific aspects of development.

Since geological prospecting and mineral research have in the past emphasized knowledge of the materials highly prized on the international market, the natural resources required for the building materials industry are often poorly known. Various African countries possess large quantities of clay, limestone, dolomite, pozzolana, gypsum, timber, other agricultural materials and wastes, industrial wastes, and other raw materials but in some countries comprehensive information on the quantity, quality and potential useage of the materials is not available. The generation of this vital information is an important step in efforts aimed at increasing the local production of building materials based on an optimum utilization of indigenous resources.

The absence of adequate energy resources constitutes, in some African countries, a real bottleneck for the development of local building materials production units. Considerable benefit could however be derived from non-conventional energy sources such as sawmill wastes, forest thinning, agricultural wastes and peat through well-conceived research programmes. Solar energy is yet another energy source that could be exploited increasingly in the building materials industry. Its use for the controlled drying of sawn timber and clay products is very well developed in some countries outside the African region.

In the area of technology for building materials production, there are potentials for the development and application of technologies that take account of the available manpower, level of skills development and financial resources. The adoption of sophisticated imported technologies in the past has only led to uneconomical ventures in many countries in the African region. The need to rediscover, improve, teach and use traditional production methods which have long been neglected is now of utmost importance.

The dependence on foreign construction companies in the execution of construction projects in Africa has not only been expensive, in terms of the outflow of hard earned foreign exchange, but has also led to a neglect of local entrepreneurs whose capabilities could be developed for the benefit of the region. There is an emergence in some of the countries of medium and large sized construction companies capable of undertaking a wide range of projects. Possibilities exist for encouraging partnerships between such companies to bid for large scale projects which are now mostly undertaken by foreign-owned companies. Programmes of assistance to indigenous contractors in the areas of finance, equipment and machinery procurement, project organization and management implemented at the national level would contribute significantly to an improvement of their performance.

There is also scope for cost-reduction in construction through the adoption of appropriate designs and techniques which would ensure the rational use of building materials and construction skills that are locally available. It is well known, for example, that up to about 40 per cent of ordinary portland cement could be replaced by a suitable pozzolana in mass concrete construction without affecting the final strength properties. And this could make available cement that could be used in constructions where its superior strength properties are required. If programmes for the increased production of local materials are not matched by schemes for their adoption in construction practice, the search for the attainment of self sufficiency in the construction sector will be greatly hampered.

In brief then, there exists in the African countries great scope for overcoming many of the current problems that confront the building materials and construction industries, and limit their effectiveness in meeting national and regional needs. Development and promotional support at the national, subregional and regional levels is an essential prerequisite for the achievement of the required improvements in these industries.

3. Priority areas for the development of the industries

The multi-faceted nature of the problems facing the building materials and construction industries in Africa requires that any programme geared to their systematic solution should be based on clearly defined priorities. Following detailed studies of the existing situation in the industries by ECA, the recommendations of African experts and the decisions of the Conference of African Ministers of Industry and the Intergovernmental Regional Committee on Human Settlements, four priority areas were defined to constitute the basis of national, subregional and regional efforts for the development of the building materials and construction industries towards the achievement of self sufficiency. The priority areas are as follows:

(i) Government policies and organizational support;

(ii) Production of building materials and development of related raw materials and other inputs;

(iii) Research and technology development including information services;

(iv) Construction services and systems.

Government policies and organizational support

To establish and sustain any viable industry, it is necessary, firstly, for Governments to formulate a general policy concerning that industry. The formulation by African governments of policies that will promote, support and guide the building materials and construction industries is therefore necessary. Viable mechanisms, including promotional institutions, for the implementation of these policies should be identified and set up.

Production of building materials and development of related raw materials and other inputs

The construction of infrastructures such as roads, bridges, airports, harbours and dams as well as the erection of administrative, community and residential buildings contribute immensely to the economic development of a country. As the construction industry depends on the building materials industry, sustained shortages in building materials restrict the development and operation of the construction industry and eventually the economic development of the country. An adequately developed building materials industry is therefore needed in each country to contribute to the economic growth of the country. The emphasis should be on the rational and optimum utilization of the resources that are available locally, giving due regard to the ability of the country to cope adequately with the technologies that are employed in the building materials industry.

Research and technology development including information services

Establishment of research organizations and formulation of a research and development programme, primarily, to identify the scientific, technological and economic bases for the industry and also to monitor progress and cause innovations and savings to be made are among the prerequisites for a viable indu try. Concerning information dissemination, because of the general limited financial resources in the region, coupled with the similarities in the problems for study which make the experiences of African countries relevant to others, it is absolutely necessary to exchange information and documentation on building research, particularly on building materials and construction. The relevance of research and technological development including information dissemination to a dynamic and viable industry cannot be over emphasized.

Construction services and systems

Successful implementation of construction programmes requires efficient construction services in addition to the provision of cheap local building materials. This is due to the fact that possibilities of increasing construction costs abound through the construction process. Costs will increase rapidly through delays, inefficiency and poor management. Unless the plannin and execution of the construction programmes is efficient and is backed by an adequate financial machinery, all the advantages gained by the production of cheap building materials will be lost. It is essential therefore to develop efficient construction services based on indigenous entrepreneurs and to introduce measures that will ensure their continued operations. It is also important to deal with existing administrative bottlenecks in the form of outdated building codes and regulations, which limit the adoption of appropriate construction techniques and systems.

The shortage of manpower of all grades leads to severe problems in the planning and implementation of construction programmes, as well as in the production of building materials and contributes significantly to the expenditure escalation of construction cost and foreign exchange. There is therefore need for the introduction of institutional facilities and regular schemes for training skilled manpower. Since this problem persists in many countries, it is an area where joint activities could be undertaken.

4. The efforts of African Governments and ECA towards the achievement of the targets of the priority areas

African Governments have in the recent past, considered the numerous problems that the building materials and construction industries face and the potentialities that exist for their development through the optimum utilization of indigenous resources including raw materials, expertise and skills. They have consequently drawn the attention of the secretariat of the Economic Commission for Africa in various fora to the need to initiate measures that would help them to develop these industries speedily to achieve self-reliance. More specifically, the Conference of African Ministers of Industry, the Follow-up Committee on Industrialization in Africa and the Intergovernmental Regional Committee on Human Settlements have considered various high priority activities required for developing the industries and urged ECA to prepare a detailed development programme in collaboration with the concerned United Nations agencies.

The Building Materials and Construction Industries Development Programme formulated by ECA in consultation with UNIDO, UNCHS (Habitat), UNEP and OAU began to be implemented in 1978 under the financing of the United Nations Development Programme (UNDP). The primary objective of this programme is to stimulate and assist African countries in increasing their capabilities for self-sustaining growth and achieving self-sufficiency in the building materials and construction industries at the continental level in the shortest possible time. The short-term objectives of the programme are as follows:

(i) To assist member States of the Commission in developing, improving and strengthening their policies, strategies and operational instruments so that they can define, co-ordinate and implement their building materials and construction industries development programmes more effectively;

(ii) To draw up guidelines for the establishment of new facilities for the production of essential building materials based on criteria of appropriate technology, self-sufficiency in basic raw materials, balanced plant size matching the size of local markets within reasonable transport distance, efficiency of capacity utilization and quality standardization;

(iii) To promote the improvement of construction systems and services and promote their re-orientation to local conditions and requirements, as well as cost-reduction;

(iv) To assist in building up and strengthening African building research and information capabilities as an instrument for modernizing existing and traditional practices.

The programme is expected to achieve tangible results of direct and substantial benefit to African countries and the region as a whole; reduction in the present very high expenditure of foreign currency to pay for imported building materials and expertise; increased employment opportunities; and general social improvement and welfare resulting from cheap housing, community facilities and infrastructure in human settlements, made possible by lower costs of building materials and construction and more efficient use of resources.

In the implementation of the programme, ECA has sponsored field missions to several countries at the invitation of the Governments. The areas of assistance covered in the missions have included appraisal of the raw materials situation, scope for utilizing available raw materials for production of low-cost building materials, improved technologies for burnt bricks and stabilized soil production, scope for increasing cement production. Missions have also been undertaken in connection with specific projects of regional or subregional character, for example, the establishment of joint subregional building and building materials research centres and the rationalisation of building codes and regulations in the light of local needs. These field missions have led to recommendations on, among others, priority projects for the indigenization of the building materials industries and the setting up of appropriate institutional mechanisms for the promotion of the industries.

The involvement of African experts at various stages in the implementation of ECA's development programme for the building materials and construction industries has provided a means of ensuring that the programme's emphasis in the selection and implementation of projects is in conformity with the priority needs in the countries. Two experts group meetings were organized in 1978 and 1979 to review the progress of activities and recommend measures for the successful implementation of the programme. In 1980 ECA organized a meeting of the Directors of African Building and Building Materials Research Institutes to identify priority research areas, modalities for enhancing co-operation among building research institutes in Africa, as well as between them and similar institutes outside the African region and recommend appropriate follow-up actions for the attention of African Governments.

The organization of a study tour cum workshop in India in April/June 1981 for a group of African experts, and the organization of an in-plant training course in November 1981 in that same country for a second group of African experts underscored ECA's desire to expose the experts to the measures adopted by, and the progress achieved in other developing countries outside the African region in the promotion of a strong, indigenous and self reliant building materials and construction industries sector in order to determine how these experiences could be adapted to suit the prevailing conditions in the African countries. These activities which provide the basis of the current report were undertaken in co-operation with the Government of India.

On their part, African Governments have not only provided the services of their experts in the implementation of the building materials and construction industries development programme, but have also undertaken measures at national and subregional levels geared to the attainment of the goals of the priority areas for these industries as identified by their officials. Creation of new facilities, and strengthening of existing ones, for the production of building materials, review of institutional mechanisms for the promotion of the industries and co-operation in preparations for the establishment of subregional research centres, are among the actions that the Governments have undertaken.

The efforts of ECA and African Governments notwithstanding, there is still much to be done in the region to bring about the complete achievement of the goal of self-sufficiency in the building materials and construction industries.

II. THE BUILDING INDUSTRY IN INDIA

This chapter deals with aspects of the building industry in India based on the findings of the study tour, workshop and in-plant training programme organized there for experts from some African countries by the Economic Commission for Africa. The subject is discussed under the following four headings:

- government policies and organizational support;
- production of building materials and components;
- research, technology development and information dissemination;
- development and management of construction services.

These areas are related to the four priority areas defined for the implementation of programmes and projects aimed at the development of the building materials and construction industries in the African region.

The presentation in this chapter is confined to a statement of the existing situation in various aspects of the building industry in India. The assessment of the relevance of the experiences gained by India in this industry to the problems prevailing in the countries of the African region is the subject of the next chapter.

1. Government policies and organizational support

The rational development of the building materials and construction industries towards the achievement of self-reliance depends greatly on the formulation of clearly defined national policies and the adoption of adequate measures to ensure their successful implementation. These measures include the establishment of the requisite institutions for planning the development of the industries, assisting the setting up of production units, undertaking research and development activities, disseminating information required by the building and construction sector, and also financing programmes in the sector.

The Government of India attaches considerable importance to science and technology as a means for achieving self-reliance in the various facets of national economic development. The emphasis in this regard has been on the development and application of small- to medium-scale non-capital intensive technologies that fit into the prevailing socio-economic and technical conditions and respond to the Government's policy for decentralization and dispersal of industries into rural and backward areas. It was to this end that the Government set up the Council of Scientific and Industrial Research (CSIR) under the office of the Prime Minister. The CSIR does not only advise the Government on science and technology policies but also participates in their implementation through research and development programmes executed by the research institutes which operate under its umbrella.

In the specific area of the development of the building materials industry, the three major research institutions functioning under the CSIR or in which CSIR is closely involved are the Central Building Research Institute (Roorkee), the Central Glass and Ceramic Research Institute (Calcutta) and the Cement Research Institute of India (Ballabgarh). Their work has led to the Government's active encouragement of the production of building materials from locally available raw materials including agricultural and industrial wastes. The support given by the Government to cement, lime, brick and tile production is reflected also in its high priority of allocation of suitable grades and

quantities of coal and railway facilities for conveyance of coal to the production and demand points. Another form of incentive is through grants to research institutions to carry out research for the industry and to establish pilot plants for demonstrating the results of research to the public and promoting the commercial utilization of the research work.

The transfer of technology from research and development institutions to potential users in the building industry is promoted by institutions such as the National Buildings Organization (NBO), the National Research Development Corporation (NRDC) and the Khadi and Village Industries Commission (KVIC). These and other similar organizations assist entrepreneurs in the establishment of commercial plants of varying sizes based on technologies developed locally and also provide advice, when necessary, on the applicability of technologies developed abroad. The NBO, in particular, promotes the adoption of newly developed building techniques in construction projects.

In the field of building construction, State organizations like the Central Public Works Department (CPWD), the National Buildings Construction Corporation (NBCC) and the Hindustan Prefab. Limited (HPL) undertake projects for the Central Government and other public institutions. Autonomous Housing Boards have been set up in each State by the State governments to undertake the construction of houses for various income groups. There are also private construction companies that assist in the execution of construction projects.

Financing of building materials projects as well as housing construction programmes very often poses a problem due to insufficiency, and this can lead to bottlenecks in implementing the Government's declared policy to improve the housing conditions of the population, particularly those in the low income group. The determination of the Government of India to avert such a situation led to the creation, in 1970, of the Housing and Urban Development Corporation (HUDCO). The main objective of HUDCO is to finance and undertake, inter alia, housing and urban development programmes, development of new satellite towns and setting up of building materials manufacturing plants. HUDCO accords higher priority to the financing of projects with a strong social bias and therefore gives special attention to projects which would benefit the majority of low income people. HUDCO levies differential interest rates on loans granted for housing construction - the lower the income of the target group, the lower the interest rate charged. HUDCO finances housing projects of the State Housing Boards. In the field of building materials industries development, HUDCO provides planning and consulting services as well as financing to State governments, semi-government bodies, public sector organizations and private enterprises. The main source of income for HUDCO is loans granted by the central government, commercial banks and life insurance companies.

The Government of India has also supported the development of the building materials and construction industries by promoting the formation of associations for building materials manufacturers. Examples of these are the All India Brick and Tile Manufacturers Federation, the Lime Manufacturers Association of India and the Cement Manufacturers Association. The associations provide the manufacturers an organized forum for serving the industry and the needs of their members on matters relating to their activities, government's policies, allocation of suitable grades and quantities of coal and railway wagons, allocation of foreign exchange for import of machinery, taxation matters, etc.

The setting up of appropriate institutions by the Government of India to take care of the multi-faceted needs of the building materials and construction industries has been an important factor underlying the successes that have so far been achieved. While it is true that some problems do still exist, it is equally true that the institutional infrastructure that has so far been created provides a sound basis for the self-sustaining growth of the industry and future progress.

2. Production of building materials and components

Building materials represent a major cost item in construction and as such, their production from local raw materials using local technologies constitutes an important element in the process of developing a self-reliant construction industry. In India, as in Africa, portland cement is a very popular building material. The advent of cement, with its superior binding properties, early strength development, easy availability in standard form and ready to use condition, led to a decline in the use of lime from the beginning of the 20th century. In recent times, however, the production of cement has not kept pace with the increased demand and this has created bottlenecks in the implementation of some construction programmes. In spite of the fact that the technology, raw materials, plant and machinery are locally available in India, the production of cement falls short of the annual demand by about 4.5 million tonnes. Heavy investments and long gestation periods have been cited as the major constraints in the expansion of the cement industry to meet the required demand.

In order to minimize the bottlenecks created by the deficit in cement, India has successfully promoted the production and use of other building materials like clay bricks and tiles, lime, pozzolana as well as materials based on industrial and agricultural wastes. The development of the use of secondary species of timber has also received priority attention. Some of the achievements of India in this field are briefly outlined below.

Burnt clay bricks

The burnt clay brick is the most popular walling material in India and it has been used in construction for many centuries. In the urban areas, buildings of up to four storeys have been erected in single leaf brick construction. Brick panel systems have also been developed for flooring and roofing purposes. In the rural areas, bricks are used for walling with thatch or local tiles for roofing.

Over 40 billion bricks are produced annually in India by the hand moulding method in 10,000 to 15,000 small units spread throughout the country. The digging and processing of clay, moulding and firing operations are carried out manually. One third of the brick production is in rural areas by clamp kilns using wood, cinder and whatever agricultural wastes are locally available. The quality of bricks produced in clamps is poor but these bricks possess sufficient strength for construction of single storeyed houses. In the urban areas the bricks are burnt in semi-permanent kilns known as bull trench kilns using coal as fuel. The capacity of plants using bull trench kilns varies from two to five million bricks per year, employing a labour force of 100 - 150. The investment cost is about US$ 0.1 million per 10 million bricks.

Mechanized brick plants are confined to some major cities. There are at present nine plants with a total capacity of 200 million bricks per year. In these plants, the excavation, crushing and mixing of clay and process of manufacture are mechanized. After mixing the clay, it is passed through an extrusion machine and the extruded brick column is cut into size using an automatic brick cutter. The bricks are then dried in an artificial dryer and burnt in a Hoffman kiln. The cost of production in the mechanized plants is almost double that in the labour intensive production units. Bricks produced in the mechanized plants are therefore not able to compete on cost with hand-made bricks even though the former possess superior strength properties and have more uniform shapes.

In order to improve the quality of hand moulded bricks, the National Buildings Organization (NBO) and the Central Building Research Institute, Roorkee, (CBRI) have introduced semi-mechanized processes using simple moulding machines. NBO has set up a demonstration-cum-production unit at Chandigarh where a soft-mud bricks moulding machine has been installed together with a traditional 'full trench' kiln. The bricks produced are better in quality and have twice the strength of local bricks. This improvement is achieved with a cost increase of US$ 1.00 per thousand bricks. In the process developed by CBRI, the clay is fed manually into the extrusion machine through a conveyer belt. The extruded bricks are carried on trolleys to the drying sheds. The bricks are then fired in a high drought kiln.

The investment and labour requirements for various types of brick production units are given in Annex II.

Cement production in small scale

The total production of portland cement in India in 1981 was about 18 million tonnes. Almost all this quantity of cement was produced in conventional large scale plants of capacity 600 tonnes per day or more. The Government of India has recognized that the large cement plants are not the answer to the diversity of the situations. The need for developing and establishing mini-cement plants (less than 200 tonnes per day capacity) in India arose because of isolated pockets of demand characterized by difficult terrain not conducive to the establishment of large-scale plants, small size limestone deposits dispersed at various locations and practical requirements for decentralization. Mini-cement plants are also ideal to match the limited availability of power, water and other inputs. Above all, the mini-cement plants, in meeting the demands of a local captive market, reduce the strain on national transportation infrastructure, make possible the participation of local smaller enterpreneurs and help to uplift the local economy.

The choice of technology for the production of cement on a small scale would have to be based on techno-economic considerations. The vertical shaft kiln (VSK) technology which has been adopted in India, offers a number of advantages over the small rotary kiln (SRK) technology. The VSK plants can be set up in very small sizes, as low as 30 tonnes per day, whereas for SRK plants, the smallest technically feasible size is

100 tonnes per day. 4/ The VSK plant also offers better thermal efficiency and less problems with dust, occupies less floor space, has a lower gestation period of 12 to 18 months compared with 30 months for SRK plant, and requires a lower capital investment compared with an SRK plant of similar size. A major disadvantage of the VSK technology is that the only fuel that can be used is coal which, in India, is a cheap source of energy compared with oil and electric power.

The assessment of limestone reserves, both in quantitative and qualitative terms, is a pre-requisite for an investment decision for setting up a cement plant. An inferred reserve of the order of 1.35 million tonnes of limestone having a lime content within the range of 44-52% is required for setting up a 50 tonne per day plant.

The Cement Research Institute of India (CRI) has developed a technology for small scale production of cement and assists interested entrepreneurs by way of technical support and consultancy services comprising raw materials evaluation, feasibility studies, project engineering, erection and commissioning of plants with the required guarantees. CRI also provides training at its main laboratories at Ballabgarh and in-plant training at its 20 tonnes per day mini-cement pilot plant at Muduvathur as part of its total package of technology transfer. Several State governments are taking advantage of CRI's assistance and have planned mini-cement plants of capacities ranging from 150-200 tonnes per day.

The capital cost of mini-cement plants worked out by the Cement Research Institute is presented in Annex III. The investment cost per tonne of installed capacity of vertical shaft kilns ranges from about US$ 67.00 for 200 tonnes per day (TPD) plant to US$ 97.00 for a 50 TPD plant. The corresponding cost for a 200 TPD conventional rotary kiln plant is about US$ 107.00.

Lime and pozzolana

Lime, alone or in combination with clay pozzolana, was the main binding material used for construction in India till 1930. With the advent of portland cement, lime lost its appeal in urban areas. Variation in quality and inherent deficiencies such as slow setting properties, cumbersome methods of preparation of mortar, poor keeping qualities and a general absence of new inflow of technology in the past contributed to the slow decline of the industry. An improved process of manufacture of lime and its controlled hydration, and also of clay pozzolana, have now helped to overcome some of the handicaps and restore lime to a position of an acceptable building material and an alternate binder to cement. The low investment (US$ 15 per tonne) required, the scope for smaller plants (20-50 tonnes per day capacity) which could be set up and operated economically at a number of locations using local materials, and at short gestation periods (8-12 months), the incentives offered by the Government of India, and the organized efforts of the National Buildings Organization(NBO), the Central Building Research Institute, the Lime Manufacturers Association and the Khadi and Village Industries Commission for the promotion, production and use of hydrated lime and pozzolana should be cited as the contributory factors for the renewed interest in lime for use as mortars and plasters, in building in place of cement.

4/ S.K. Chopra. "Cement production in small scale". Paper presented at the Workshop on the development of the building materials and construction industries in Africa based on Indian experiences. New Delhi, June 1981.

Lime

Lime, like brick, has three levels of technology for its production, namely, labour-intensive, semi-mechanized and fully mechanized technologies. India has all the three levels of technology for producing lime as evident in several states. In some places, for example, New Delhi, Dehradun and Satna, there is a historic concentration of lime plants.

Special mention should be made about the widely prevalent practice of production of lime in cottage scale units in India by traditional methods of burning limestone in country kilns using as fuel, cow-dung cakes, cinder, wood or any agricultural waste available locally. In this way, local self-sufficiency is being achieved. However, the lime produced by this method is of varying quality because of inadequate control of the burning process. The Khadi and Village Industries Commission (KVIC) promotes these small industries by providing advisory services, financial assistance, improved technologies, as well as trainin . More than half a million tonnes of lime are produced annually by the cottage scale units and are used in the rural areas for agriculture and housing construction.

In the small and medium scale sector, there are about 300 lime kilns of capacities ranging from 10 to 50 tonnes per day. The total production from these units, amounting to about 1.5 million tonnes a year, constitutes the main supply of lime to the building industry. Cylindrical vertical shaft kilns, usually with refractory brick lining, are used. Limestone crushed to size is mixed with coal in a ratio of about 75 per cent to 25 per cent and fed into the kiln from the top either mechanically or manually. The burnt limestone is discharged through three gates at the bottom of the kiln. Well burnt limestone is obtained around 72 hours after commencement of the firing operation. The process is continuous whereby as burnt limestone is discharged from the bottom, raw limestone mixed with coal twice the amount discharged, is fed in from the top.

Some of the small and medium sized units have installed mechanical hydrators which help to produce hydrated lime of good and uniform quality. Hydrators designed by the Central Building Research Institute at Roorkee have been installed at a number of plants.

There are also a few large scale sophisticated plants with capacities of about 150 tonnes per day. These plants are owned by companies in the Chemical industry who consume the output from the plants. The lime produced is therefore not available to the building industry.

Investment costs of lime plants with capacities ranging from one tonne per day to 50 tonnes per day are given in Annex IV. The investment cost per annual tonne is about 12.5 US dollars for a one tonne per day plant and 33 US dollars for a 50 tonne per day plant with a mechanical hydrator.

Pozzolana

Pozzolana is a material which, while having no cementitious value in itself will, in finely divided form and in the presence of moisture, react chemically with calcium hydroxide to form compounds with cementitious properties. Pozzolanas can therefore be mixed with portland cement or clinker to produce portland pozzolana cement or mixed with lime to produce lime-pozzolana.

In India, two types of pozzolana are in common use, flyash and surkhi (burnt clay). In more recent times, the development of rice husk ash as a pozzolana has also assumed increasing importance. About 8 million tonnes of flyash is available per annum from 42 thermal power stations which use pulverized coal in their boilers. The flyash is however used on a limited scale as a partial replacement of cement to produce pozzolana cement and in lime pozzolana mixtures. By far the most popular pozzolana is surkhi which has been in use for hundreds of years. The Taj Mahal in Agra, for example, was built using a lime-surkhi mortar.

The surkhi commonly in use is obtained by grinding burnt brick bats but the pozzolana obtained has generally poor pozzolanic activity. A number of processes have been developed for the calcination of certain types of clay to yield good quality pozzolana. These include processes using downdraught, vertical shaft and rotary kilns. Another process, developed by the National Buildings Organization in collaboration with the Sriram Institute for Industrial Research, New Delhi, is the fluidized bed technique. Plants utilizing this process, with a capacity of 15 tonnes per day of clay pozzolana, are commercially available in India at an investment cost of about US$ 75,000.

In order to make available a binder material in a readily useable form, lime pozzolana mixtures made by intergrinding lime and clay pozzolana with a small percentage of gypsum to improve early strength characteristics, and conforming to published national standards, have been developed and are being marketed. This material has been found to be popular with private house builders.

Another pozzolana material which is becoming increasingly popular in India is the ash obtained from the burning of rice husk. India is the largest producer of rice in the world with a total annual production of about 75 million tonnes of paddy which yields nearly 15 million tonnes of rice husk waste from the paddy hulling plants.

The bulk of the husk is disposed of by burning it or is used a low-grade fuel in the countryside and also for raising low-pressure steam for parboiling of paddy. A very small amount is used for making fibre boards, detergents, bricks and as packing material.

The Cement Research Institute of India has developed a simple technology for the production of a cementitious binder through the intergrinding of lime with the ash obtained from the controlled burning of rice husk in an incinerator. This binder material is known as rice husk ash masonry cement (RHAM cement).

A 5 tonne per day RHAM cement plant based on the CRI technology has been in operation successfully at Nilokheri, 140 km from New Delhi and located in a rice growing area, since March 1981. The African experts who participated in the in-plant training organized by ECA in India (October/November 1981) had the opportunity to visit this plant. The main components of the plant are a battery of incinerators for burning the rice husk to ash, a kiln for producing lime from limestone, and a ball mill for intergrinding the rice husk ash and lime to produce RHAM cement. The total investment in the plant was approximately 130 Indian rupees per annual tonne (about US$ 15.00 at the time). The selling price of RHAM cement in November 1981 was US$ 73.5 per tonne compared with US$82.3 per tonne for ordinary portland cement.

Rice husk ash masonry cement has been found suitable for some construction activities, particularly in the rural areas - housing and other building construction (for making blocks, as mortar and for plastering), canal linings, grain storage bins, specialized applications for making acid-resistant concrete needed for food and fertilizer industries where conventional portland cement cannot be used, etc. RHAM cement is however not recommended, at this time, for use in reinforced concrete constructions.

Timber and allied products

Wood and wood based products are used extensively in building construction in India in both the urban and rural areas. The consumption of timber in the construction industry alone in India is estimated to be 3 million cubic metres per year. However, present projected demand and supply estimates indicate that there would be an acute shortage of good timber of upto 50 per cent by 1985. This challenge is being met through the application of modern tec niques in wood science and technology for the proper management of forests and the development of wood products. It is estimated, for instance, that the adoption of modern timber techniques by exploiting the large number of lesser known or secondary species of timber would result in saving in timber consumption to the tune of 50 per cent. The results of studies undertaken by the Forestry Research Institute, Dehradun, on these species of timber have helped to avert a situation in which acute scarcity and rising costs were beginning to oust timber as a constructional material despite its established reputation. Various methods of joining timber components using nails, bolts, timber and bamboo pins, ring connectors, glue and timber disc dowels have been successfully developed for use by industry. Other developments have included glue laminated construction and large span timber trusses. Other conservation measures adopted to avoid wastage of timber resources include the seasoning of timber, wood preservation and conversion of wood waste into useful building materials.

As a result of various actions taken by the Government of India, including familiarazing major construction companies, engineers and architects with the benefits of using processed and treated wood through seminars and symposia; setting up treatment plants for secondary species of timber; constructing demonstration houses in forest zones; and modifying the schedule of rates of the Central Public Works Department, State Public Works Departments and State Housing Boards to include the use of treated timber, some progress has been achieved in encouraging the use of the secondary wood species in construction.

Bamboo and some types of grass with short production cycles are now being seriously developed as building materials for walling as well as roofing. For example, bamboo pressed boards have been developed and used successfully for roofing. The technology for the use of bamboo as a reinforcing material in lieu of steel in reinforced concrete construction is very well developed and is being promoted for use in low cost housing projects.

Use of industrial and agricultural wastes

The processing and utilization of industrial and agricultural wastes for the development of building materials is being given top priority in the programmes of building research institutions in India. This is important both from the point of view of achieving maximum disposal of the wastes and conservation of conventional and scarce resources and materials. Some of the achievements by the research institutes are mentioned below.

Studies have shown that granulated blast furnace slag (containing a high percentage of manganese oxide) and phosphogypsum (a waste material from fertilizer plants) could be useful inexpensive raw materials for the manufacture of slag cements and building plaster and plaster boards. Slag and waste lime sludge from sugar, paper and carbide-acetylene gas plants can be used for making masonry cements. The burning of dry mixtures of lime sludges and rice husk produces a low cost cementing material. Red mud waste from aluminium industries, water works silts and slate wastes have been found useful for making good quality bricks and lightweight aggregates.

Extensive researches on the utilization of fly-ash from thermal power stations which use pulverized coal as fuel in their boilers have led to recommendation of its use as a partial replacement of portland cement in in-situ concrete, in mortars and plasters, and in making sintered lightweight aggregate. Several mining wastes such as those from the beneficiation of iron, zinc, copper and gold ores have been found suitable for making sand-lime bricks, cellular concrete or lime stabilized bricks.

Agro industrial wastes such as rice husk, coir fibres coconut husk and pith, rice straw and groundnut husk have been used in developing cement-bonded wall boards and corrugated roofing sheets.

Although there is a great potential in India for the manufacture of building materials from industrial, mineral and agricultural wastes, it appears only a few processes out of the large number investigated have been translated into industrial production. The reasons for this are varied. For example, even though the Central Building Research Institute at Roorkee has done significant studies on the production of sand-lime bricks, commercial production and large-scale use of these bricks in India is not possible at this stage because of the availability of cheaper burnt clay bricks.

Roofing materials

Clay tiles

Clay tiles constitute the major roofing material besides asbestos cement sheets and galvanized iron sheets. There are about 600 units producing over 600 million roofing tiles of the Mangalore pattern annually. At village level, the tiles are moulded by hand and fired in simple kilns using firewood and dried cow-dung as fuel. On a commercial scale however, a semi-mechanized process is usually employed. The clays are stored in heaps after excavation and left to weather for at least six months before being used. The machines generally used are a box feeder for proportioning the clays if more than one clay type is being used, high speed rollers for grinding the clays, a double-shaft-mixer, a de-airing pugmill for extruding clay bats and semi-automatic presses for pressing the bats into tiles. Drying of the pressed tiles is carried out partly in the shade in natural dryers using fans and partly in artificial dryers. The tiles are fired in Hoffman type kilns using firewood, coal or oil. Firewood is the most commonly used fuel. Cashew nut shells are also used as fuel in some plants.

Corrugated asphaltic roofing sheets

Corrugated roofing sheets are being manufactured in India from asphalt and paper felt, as a substitute for galvanized iron and asbestos cement sheets. The process of manufacture consists essentially of reducing the basic raw materials - waste paper, rags and other cellular fibres - to a wet pulp of the required finess in hammer mills

and then forming the pulp into sheets in felt or board forming machines. The resulting cardboards are sun-dried, cut to size and corrugated in a press. The corrugated sheets are dipped in a hot asphaltic bath for about 30 minutes, air cured and finally coated with an aluminium paint.

The corrugated asphaltic sheet is claimed to be about 30 per cent cheaper than any of the other roofing materials available in India. In terms of strength, resistance to water, heat and fire, it gives satisfactory performance. It is recommended for use in place of thatched roofing particularly in areas where the temperature does not exceed 40°C. The application of this product in building construction has so far been limited to poultry and cattle sheds and temporary shelter. Its major deficiency is softening and sagging when exposed to high temperatures. The investment for a plant of capacity 10,000 sheets per day was estimated to be about 2 million US dollars in 1981.

Other building materials

Cellular concrete

Cellular concrete is a lightweight material manufactured from sand/fly ash, lime/cement and gypsum. It is used in making blocks, bricks, flooring and roofing elements for building construction with considerable saving in steel and cement. Its lightweight permits large sizes of blocks and panel elements to be handled and this results in savings in labour, mortar and construction time.

The process of manufacture of cellular concrete involves mixing a fine sand slurry (or fly ash slurry) and a binder mix (finely ground mixture of sand or flyash, lime or cement, gypsum if lime is used) thoroughly and adding emulsified aluminium powder. The aluminium powder reacts chemically with lime to liberate hydrogen gas which leads to an increase in the volume of the setting mass, making it lightweight. After cutting into the desired shapes and sizes, the products are autoclaved under saturated steam pressure to attain the required strength properties.

The Tamilnadu Housing Board in Madras has set up a cellular concrete plant and is using cellular concrete blocks instead of clay bricks for walling in its building construction programme for various income groups and reported 50 per cent savings in mortar requirements. The Board has also used cellular concrete blocks as composite slabs with ordinary concrete and nominal steel reinforcement for roofing. Savings of up to 50 per cent in steel, 20 per cent in cement, up to 70 per cent in wood shuttering and up to 80 per cent in water useage have been achieved in this regard.

Latoblocks

Lateritic soils which are abundant in many areas of India have been used to manufacture good quality building blocks. The soil is mixed with a small percentage of lime and then moulded in a block press. Two types of press developed by the Structural Engineering Research Centre, Madras (which is an organization set up by CSIR) are in use: a low-cost labour intensive machine with a production capacity of 1 500 bricks a day and a semi-automatic machine of 6 000 bricks a day capacity. Latoblocks offer a number of advantages including low water absorption, dimensional stability, good plasterability, weather resistance and low energy consumption since firing is not required in the production of the blocks.

Stoneware pipes

Stoneware pipes are used in India exclusively in all gravity drainage works of up to 45 cm. diameter. The pipes offer the advantage of longer life span and less cost compared to concrete and other pipes. Stoneware pipes have been known to be in use for over 70 years without any damage. The African experts in the study tour group had the opportunity to visit Mysore Stoneware Pipes, a private factory in Bangalore, where semi-mechanized methods are used in manufacturing such pipes.

The process of manufacture involves the manual blending of the variety of clays needed to give the required plasticity, and moulding the pipes in an extrusion machine after grinding and mixing the clay with a predetermined amount of water. The products are then air-dried and burnt in downdraught kilns. Coal or oil are the major fuels used in the firing operation; firewood has also been used in some cases with success.

3. Research, technology development and information dissemination

Economy in the cost of construction and consumption of scarce resources is a matter of great importance in national development strategies. Research and development in the total building process plays a significant role in the achievement of economy in construction. India has long recognized the importance of such research and development work in the building and housing sector and has placed great emphasis on the establishment of research institutions. Research institutes such as the Cement Research Institute (CRI), New Delhi, the Central Building Research Institute(CBRI), Roorkee, the Structural Engineering Research Centre (SERC) at Roorkee and Madras, the Forest Research Institute (FRI), Dehradun and the Indian Plywood Industries Research Institute (IPIRI), Bangalore, which the African experts had opportunity to visit and other research institutes provide vital support to the building industry.

A common problem in many developing countries relates to the inability to ensure that the results of building and building materials research are translated into commercial production activities as well as architectural and engineering practice. The establishment of the National Research Development Corporation (NRDC) and the National Buildings Organization((NBO) have helped greatly in addressing this problem in India.

Organization of research and development activities

Scientific and technological research in the public sector in India is carried out mainly under the umbrella of the Council of Scientific and Industrial Research (CSIR) by many research institutes. The Council co-ordinates and supervises the activities of the research institutes and advises the Government on national scientific and technological research policy and priorities. The operations of CSIR are funded directly by the Government of India.

Two types of research institute operate under the aegis of CSIR - those that are administered and financed wholly by the Council, such as CBRI, SERC and FRI, and those administered and financed jointly by the Council and the industry, such as CRI and IPIRI.

Universities in the various states of India also undertake a lot of scientific and technological research. The location of some CSIR institutes near the campuses of universities, like CBRI and SERC in Roorkee, has helped greatly in fostering co-operation in research and promoting the sharing of facilities and experience.

The direct involvement of the Industry in building and building materials research has had beneficial effects. The research programmes of the concerned institutes are formulated in consultation with the industry. The institutes receive a continuous feed-back from the industry based on production trials of the processes developed by the institutes. The problems and projects taken up by the industry-sponsored research institutes therefore remain practical and while serving the interests of the industry, often have a significant bearing on problems of national importance, for example, mass housing.

Financing of research and development activities

Research in any field of human endeavour is an expensive venture and yet without adequate funding for research programmes, the expected results may not be fully realized. As already mentioned above, the Council of Scientific and Industrial Research is financed by the Government of India through an allocation in the national budget. The recognition by the Government that science and technology has an important role in bringing about a self-reliant and self-sustaining development process has been crucial in ensuring the Government's continuing support to the activities of the national scientific research institutions.

The building materials manufacturing industry has also played a leading role in the provision of financial resources for the development of research capabilities in India. The Cement Research Institute of India at Ballabgarh and the Indian Plywood Industries Research Institute (IPIRI) at Bangalore are examples of co-operative financing of research institutions by the Government, the industry and the CSIR. In both cases, the contribution by the industry is realized through a cess levied on plywood/cement manufactured in the country. During the first 15 years of its existence (1962-1977), the total expenditure of IPIRI was 17.8 million rupees (about US$ 1.8 million). Out of this, the contribution by the plywood industry was 9.5 million rupees. Grants from CSIR during the 15-year period totalled 7.9 million rupees. 5/ The Cement Research Institute (CRI) is financed primarily from funds obtained by imposition of a tax of 0.5 rupee on every tonne of portland cement produced in India. At current production levels the amount realized from this source is nearly 10 million rupees (about US$ 1 million) per annum.

Application of research findings and information dissemination

The National Research Development Corporation (NRDC) was established about 30 years ago to ensure the proper and co-ordinated follow-up of the research and development work carried out by national research institutes in the field of science and technology and to bring about speedier application of newly developed processes and techniques in pilot plant trials or commercial ventures. NRDC is the custodian of all such processes and techniques including patents taken by the research scientists and is authorized to grant licences to interested entrepreneurs to utilize them in commercial ventures. NRDC may therefore be described as the link between scientific research and its utilization in India.

5/ "IPIRI completes fifteen years of service to the industry". Booklet issued by IPIRI, Bangalore in 1977.

An important aspect of the work of NRDC is the setting up of demonstration projects based on newly developed technologies as a means of encouraging the wider adoption of such technologies. Some of the activities are undertaken in collaboration with financial institutions, service organizations, voluntary organizations and others interested in the development and promotion of indigenous technologies.

The National Buildings Organization (NBO) was established in 1954 under the Ministry of Works and Housing to study the problems of housing at the national level and to initiate or promote activities for the betterment of housing conditions.

Thus, whereas NRDC has responsibility for technology transfer in the field of science and technology as a whole, NBO deals with the specific problems of housing and related matters. The activities of the two organizations are therefore complementary as far as the housing sector is concerned.

An important aspect of the activities undertaken by NBO concerns the transfer of technology and research findings from the research institutes to the building materials and construction sector with a view to ensuring the reduction of cost in building and housing.

The National Buildings Organization, acting as a liaison institution between research centres and the construction industry, has used various methods to promote the acceptance of research findings by the industry. These have included the construction of full-scale experimental buildings utilizing new techniques and materials; erection of demonstration houses to give first hand knowledge of the practical application of new techniques and materials in construction; setting up of demonstration plants for the production of building materials to demonstrate the viability of newly developed processes and techniques, train personnel deputed by prospective entrepreneurs interested in setting up similar plants and conduct test evaluation of raw materials required for production; organization of displays and exhibitions to draw the attention of engineers, architects and builders to technological progress and developments in research. Other methods of information dissemination adopted by NBO have included the publication and distribution of technical documents, the organization of film shows, discussions on radio, seminars, symposia and training courses.

The effectiveness of the activities of NBO is enhanced by its nine rural housing wings set up at engineering or architectural colleges in different parts of the country. In this way the problems of various regions of the country are given the specific attention that they deserve.

The existence of the National Research Development Corporation and the National Buildirgs Organization provides the means to ensure that at the national level, concerted and co-ordinated efforts are made to promote the development and adoption of scientifically based and locally relevant technologies for the housing and building sector in India. NRDC and NBO therefore work in close collaboration with the research and development institutions in the area of technology development and transfer, as well as information dissemination.

Achievements of research and development institutions

It is not possible in a document of this nature to give a comprehensive coverage of the successes achieved by the Indian research and development institutions in the field of housing and building. However a brief description is given below of the major achievements of the five research institutes that the African experts had the opportunity to visit during the study tour and in-plant training. 6/

Cement Research Institute of India (CRI)

CRI is a centre for intensive and co-ordinated research on the manufacture and utilization of cement. The activities of the institute are mainly geared towards the development and promotion of new technologies in cement production including cement making machinery, promotion of productivity, increased efficiency, improved product quality, conservation of energy and cost reduction in the cement industry. Among the projects successfully concluded by the institute, and which have found application in industry are: utilization of fly ash from thermal power stations for the manufacture of portland pozzolana cement; development of mini-cement plants; utilization of agro-waste materials such as rice husks for the manufacture of a cementitious binder; design of reinforced and prestressed concrete poles for rural electrification; development of efficient packaging for cement.

In addition to providing consultancy services, CRI also undertakes manpower training for the cement industry and offers industrial information services.

Central Building Research Institute (CBRI)

The main objective of the Central Building Research Institute at Roorkee is to assist the building industry in solving problems of planning, design and construction in urban and rural areas with a view to achieving speed and economy in building construction. The institute has successfully accomplished a large number of applied and development projects. For example, in the field of foundations, the institute has developed short bored pile foundations suitable for black cotton soils which usually pose severe foundation problems, resulting in cracks in buildings. Successful investigations have also been carried out on the utilization of industrial and agro-wastes such as fly ash, slag, coir fibres, rice husks, lime sludge and sawdust for the production of building materials. Prefabricated roofing and flooring units which lead to economy in construction have also been developed at the institute. Other developments have included a semi-mechanized process for the manufacture of burnt bricks, improved lime kilns and hydrators, methods for water proofing of mud walls, and solar water heaters.

CBRI also provides extension and information services. The institute maintains direct liaison with industry and other users through seminars, symposia, conferences, demonstration of new techniques, including factory trials of new products and techniques. Several dwelling units, schools and clinics incorporating new materials, techniques and systems developed at CBRI have been built in various states in India.

6/ Addresses of the research institutes and other relevant organizations are provided in Annex V to facilitate requests for further information.

Structural Engineering Research Centre (SERC)

The Structural Engineering Research Centre operates from two campuses at Roorkee and Madras with the primary objective of undertaking applied research on all aspects of structural engineering in consonance with national priorities.

One of the outstanding achievements of SERC has been the development of unreinforced funicular shells for roofing industrial, institutional and residential buildings, as well as the construction of intermediate floors in multi-storey buildings. Funicular shell roofs of up to 36 metres by 14 metres have been designed and constructed in some cases. The most extensive application of these roof structures has been in building residential colonies through the use of mass-produced precast funicular shells of a size small enough to be handled manually without the use of hoisting equipment.

SERC has made a significant contribution in the area of import substitution by developing grip bars for concrete reinforcement. Over US$ 20 million worth of this steel product has already been produced and marketed by a local entrepreneur based on SERC know-how. Other products and techniques developed by SERC include grain storage bins and water tanks made from ferrocement, prestressed concrete sleepers and poles, large panel prefabrication systems, stabilized soil block machines and the use of flyash for partial replacement of cement. The Centre has also undertaken consultancy assignments involving the design of large and complex structures of unusual features for both public and private organizations. SERC organizes short-term specialized courses in structural engineering for practising engineers from time to time.

Forest Research Institute (FRI)

The Forest Research Institute at Dehradun, is charged with the responsibility of undertaking research on the development, conservation, preservation and utilization of forest products, especially wood. The institute has colleges for training manpower in the field of forestry. In the field of building and construction, the activities of the institute include timber mechanics and engineering; wood seasoning and preservation; technologies for processing secondary and inferior species of wood for constructional purposes; efficient use of waste wood as a building material.

Some of the significant achievements of FRI have already been highlighted in the section on production of building materials and components. In the field of preservation, the institute has developed a number of treatment processes, notable among which is the one utilizing ASCU, developed in 1934 and which has been used in many countries around the world. In 1972, FRI developed a solar kiln for controlled seasoning of timber which is now under commercial application. The institute has successfully promoted the use of secondary species of timber in structures and this has helped greatly in reducing the cost of construction in timber. Much development work on the use of bamboo as a reinforcing material in reinforced concrete has been done and field applications in low cost housing projects are being undertaken. FRI also runs courses for technicians, wood technologists, architects, engineers and builders on timber design and construction techniques.

Indian Plywood Industries Research Institute (IPIRI)

The Indian Plywood Industries Research Institute at Bangalore, which is a joint venture of the Plywood Manufacturers Association, the Council of Scientific and Industrial Research and the Ministry of Industry, is mandated to carry out research

and development work for the plywood, particle board and allied industries. The important areas of activities at the institute include research into the process of manufacture of wood veneer; development of adhesives for plywood and glued laminated components; utilization of plywood and allied products in housing; utilization of plywood as a structural material; improvement of quality and productivity in plywood factories; dissemination of information and transfer of technology to the industry.

Notable achievements by IPIRI have included the development of low-cost roofing using wood veneer waste, and also bamboo pressed boards. A portable house designed for use in disaster prone areas has also been developed. The use of plywood in load bearing structures, such as I-beams and other structural components has been successfully promoted by the Institute. IPIRI has also developed silos made of plywood for the storage of grains; silos of upto 25 tonnes capacity are now being increasingly used.

4. Development and management of construction services

The successful implementation of construction programmes requires the availability of sound construction services in addition to the provision of clean and readily available building materials. Construction costs tend to increase rapidly through delays, inefficiency and poor management practices that characterize the operations of inadequately developed construction services. Unless there is efficient planning and organization backed by adequate schemes for financing construction companies, all the advantages gained through the production of cheap building materials will be to no avail.

In India, almost all construction projects are undertaken by indigenous construction companies both in the public and private sectors. As mentioned earlier in the discussion on institutional support provided to the construction industry by the Government of India, steps have been taken to facilitate the implementation of public projects through the creation of various organizations.

The Central Public Works Department (CPWD) is the Central Government department responsible for the implementation of all its construction projects. It undertakes the planning, design and engagement of contractors for the execution of projects. CPWD therefore has great influence in the choice of building materials and construction technology for central government projects. In many cases, CPWD provides contractors with the major building materials required for projects (for example cement, steel, bricks, etc.). At State level, State public Works Departments provide similar services.

The National Buildings Construction Corporation (NBCC) is a public sector enterprise set up in 1960 and entrusted with the responsibility of undertaking public constructions. The main objective of NBCC is to achieve the efficient, economic and timely execution of constructions. It also undertakes responsibility for the supervision of projects on behalf of clients; provides consultancy services in manpower planning, quality control and technical auditing of construction works; and undertakes turn-key services involving project planning, design and implementation. NBCC which is now one of the biggest construction companies in India, has also undertaken projects overseas, particularly in Libya and Iraq.

The Hindustan Prefab Limited (HPL), a specialized agency in the field of prefabrication, was established in 1953 as a public sector enterprise. It renders services covering all phases of planning, design, manufacture, supply and construction of prafabricated structures for industrial, commercial and residential purposes. HPL also offers turn-key services for setting up prefabrication plants for the production of components both in India and abroad.

Private construction companies of diverse sizes and capabilities also play an important role in the execution of construction projects in India; in fact, they undertake the major proportion of projects in the country. Organizations like the Delhi Development Authority and the State housing boards which construct large numbers of housing units annually use mostly the services of qualified private contractors.

The organization of courses and workshops by research institutions and promotional agencies helps to prepare construction companies to adopt new building materials and construction techniques in field projects. Technical consultancy services provided by the research institutions and agencies like the National Buildings Construction Corporation also promote the strengthening of the capabilities of indigenous construction companies.

The success of project implementation in the construction sector depends also on the availability of adequate financing. In this regard, the efforts made by the Government of India in the field of housing is noteworthy. The Housing and Urban Development Corporation (HUDCO), a financing institution established in 1970 by the Government of India, among other activities, grants loans to the State Housing Boards for the construction of housing estates. This helps not only in providing houses for various income earners, but also provides opportunities for some building contractors to increase their wealth of experience in project execution. The Tamil Nadu Housing Board, for example, awards design and construction contracts on a preferential basis with incentives to groups of engineers and architects with a view to encouraging entrepreneurial skills.

India has built up over the years the capacity to handle, through local entrepreneurs, the execution of its construction programmes. This achievement has resulted primarily from the priority accorded by the Government to the development of the construction sector which has been expressed in the establishment of the appropriate institutions and the implementation of measures to promote the operations of indigenous construction companies.

III. INDIAN EXPERIENCES AND THE BUILDING INDUSTRY IN AFRICAN COUNTRIES

India has achieved significant successes in containing the problems that have confronted the building construction industry. This has been the result of the various measures that have been taken by the Government pertaining to the different phases of the building process, from the production of building materials through to the management of building construction services. India has also laid great emphasis on the development of indigenous technology through research, and the means for achieving the speedier application of research results in the field.

This section of the document examines the experiences of India in the building construction industry in the light of the prevailing socio-economic and cultural conditions in Africa, and draws attention to aspects of these experiences which could find application in the African context.

1. Policies and organizational support

The achievement of a high degree of self-reliance in the building materials and construction sector in India has been greatly assisted by the existence and effectiveness of institutions set up by the Government to deal with various aspects of the sector, including planning, design, project implementation and management, project financing, research and information dissemination. These institutions were set up in the wake of clearly defined government policies geared to the promotion of an increasing measure of self-reliance in the various facets of national economic life based on the application of science and technology.

In many African countries, some institutions have been set up to deal with the development of the building materials and construction sector but gaps still do exist in some countries. Research and development activities have not always been given the desired emphasis, and some countries lack building research institutes. Promotional institutions like the National Buildings Organization, New Delhi, do not exist in many African countries. Many countries also lack adequate mechanisms for financing housing programmes specially for low-income earners.

Africa consists of countries of different sizes, factor endowments and economic potential, and this means that the types of institutions required in the countries may differ. The experiences of India, nevertheless, provide examples that could be examined by individual African countries in the light of their specific needs. It is essential however that African Governments give adequate financial and technical support to public institutions set up to promote the development of the building materials and construction sector so as to enhance their effectiveness in the performance of their roles.

2. Building materials and components

The high priority accorded to the local production of building materials from available raw material resources has underpinned the success achieved in reducing shortages in the supply of building materials for construction projects in India. In addition to upgrading conventional materials like cement, brick, steel and timber, and developing techniques for their efficient use in construction, efforts have also been made to promote the development and use of new types of building materials which could serve, in some cases, as partial or complete substitutes for the conventional materials. The production of a low-cost binder material from rice husk ash and lime is an example of such efforts.

Improvement of traditional production technologies as a means of increasing productivity and enhancing improved product quality has also been promoted. This has been pursued, very often through partial mechanization rather than adopting wholesale highly capital intensive methods, thereby making use of the abundant labour in the country. For example, in the manufacture of lime, India has provided a face-lift to the industry by developing a mechanical hydrator to provide high quality lime but at the same time maintaining the traditional labour intensive nature of the industry. When it has been necessary to import technology for the manufacture of building materials, as in the case of the cellular concrete and and asphalt roofing sheets plants, the import content has been kept to a minimum.

The building materials industry in India uses coal as the primary source of fuel. Even though there are abundant supplies of this fuel, bottlenecks in the rail transport system sometimes create problems of availability. In order to forestall the frequent occurrence of such situations, the Government accords priority to the needs of the industry in the allocation of railway wagons for the transportation of commodities across the country.

The development of the local building materials industry in India, is thus based on the maximum exploitation of the resources that are readily available - raw materials, coal and other fuels, abundant labour. The technologies that have been developed for the industry have been determined by the kinds of resources available and by local needs.

Africa, like India, enjoys abundant availability of raw materials like limestone, clay and timber which could be converted into useful building materials, but has not fully utilized them for a number of reasons. In the main, Africa has suffered from the tradition of dependency on imported ready made products from developed countries to the extent of neglecting the development of available traditional skills in brick-making, lime manufacturing, etc. Even when the development of the local raw material resources have been planned, the general tendency has been to adopt sophisticated and capital intensive technologies which have not only drained hard earned foreign exchange but have also required imported skills, the absence of which has sometimes led to the collapse of production plants.

The philosophy upon which the building materials industry in India has been developed fits in very well with the philosophy of self-reliance embodied in the Lagos Plan of Action, which is the blueprint for Africa's economic and social development during the next twenty years. The experiences gained by India can therefore provide an input into the efforts being made in the countries of Africa to achieve an increasing measure of self-sufficiency in the building materials industry. It is important however to give due consideration to the specific conditions in the different countries of the African region.

Firstly, the labour intensive technologies that have successfully been used to produce the bulk of such materials as burnt bricks, clay tiles and lime would have to be studied further to arrive at suitable labour-capital ratios, since labour costs in the majority of African countries are higher than those pertaining in India. Secondly, since coal which is the primary fuel used in the building materials industry in India is available only in a few African countries, redesign of some of the plants in respect of energy input would have to be considered.

For example, during the technical workshop which was held after the study tour by the first group of African experts, 7/ questions were posed on the scope of using other sources of energy, like oil and electric power instead of the low-volatile coal that is currently being used in India for the production of cement in mini-cement plants based on the vertical shaft kiln technology. It was explained that the development of technology for using these sources of energy had not received attention in India since coal was abundant and had been found to be, and remained, the cheapest source of energy. However, in some cases, as in lime production, the kilns used in India could, with only minor modifications, be operated using firewood and oil as fuel.

The promotional measures that have been adopted for increasing the use of indigenous building materials in India, including the formulation of appropriate standards and the construction of demonstration buildings, should engage the priority attention of African Governments. It is also important to have precise information about locally available raw materials and their potential uses as a basis for planning programmes for their optimum utilization to meet the needs of the construction industry for building materials in various locations in a given country. The choice of plant sizes should depend on the economic circumstances and the technical needs of the country, the need to create employment opportunities and should also give due consideration to the concept of decentralization of production.

3. Promotion of research and indigenous building technology

Research and development programmes have been given a high priority in the development policy of India and this has contributed greatly to the successes that have been achieved in the building materials and construction sector. The Council of Scientific and Industrial Research plays an important role in the formulation of research policies and has the Prime Minister as its President. Research and development programmes therefore enjoy the full support of top Government policy makers. The autonomy given to research institutions in their operations and the level of resources put at their disposal have helped greatly in enhancing their effectiveness.

Basically, India has a mixed economy in which the private sector plays a significant role; this extends to the administration and funding of research and development institutions. Equally important is the extent to which the industrial sector appreciates the need for research work, recognizes the findings of research work as of importance to itself and contributes to the development of research and the commercial application of such findings. It is well represented on the Boards of management or the Scientific Advisory Councils of the research institutions and hence, is closely involved in their activities. National institutions like the National Research Development Corporation and the National Buildings Organization also assist in promoting the field application of the results of research work.

7/ Report on Workshop on the development of the building materials and construction industries in Africa based on Indian experiences, ST/ECA/HUS/3, October 1981.

Research and development activities in the field of building materials and construction have not always received the priority attention of many African governments. It is clear however, from the experience of India that the maximum exploitation of local raw materials for the production of building materials as a means of promoting self-reliance in the construction sector cannot be achieved without an effective, locally relevant research and development base. The co-ordination of scientific and technological research at the national level as well as the promotion of the adoption of newly-developed processes and techniques in the building industry through institutions akin to the Council of Scientific and Industrial Research, the National Buildings Organization and the National Research Development Corporation should be accorded increased priority attention.

African Governments need to review the current level of manpower and financial resources made available to existing research institutions with a view to strengthening them, where necessary. The Governments should also explore the possibilities of encouraging the industrial sector itself to assist in the financing of research and development activities and to make use of the research results. In this connection, the idea of levying a "cess" on certain building materials as a means of generating funds to support research should merit a serious evaluation. Some countries may have to determine the desirability of setting up new centres to undertake research in the field of building materials and construction. This assessment should give due consideration to the possibilities that may exist for joining other countries in establishing subregional research centres to serve the needs of the participating countries.

In order to remove bottlenecks that hinder the ready application of research findings, steps should be taken to: evolve suitable policies and incentives; educate engineers, architects and other technicians on new building techniques and systems through seminars and courses and also at the universities; organize training programmes for middle-level technicians and artisans; increase resources available for dissemination, particularly for the establishment of pilot/demonstration projects.

Research has contributed significantly to the use of improved building materials in the rural areas of India and African countries could benefit from some of the Indian experiences relating to materials production technologies, building construction techniques and systems, and improvement of the durability of materials used in construction, especially timber. In this connection it would be helpful for building and building materials research institutions in African countries to establish channels for information exchange with their counterparts in India. This will assist in determining which processes or techniques can be applied directly and those that can be adapted with suitable modifications for application in individual countries in the African region.

4. Development of construction services

The situation regarding the implementation of building and construction projects in the majority of African countries is that the bulk of the important and high-valued projects is executed by foreign based construction companies while most of the indigenous contractors have capacities to undertake only minor and low-valued projects. The cost of project implementation in terms of foreign currency expenditure therefore tends to be high, a situation many countries are finding increasingly difficult to sustain.

The problems of several local contracting firms, particularly the smaller ones, include lack of access to finance to purchase machinery and equipment, and also to commence projects without advance payments; general technical incompetence due to lack of formal training and unwillingness sometimes to engage the services of qualified technical staff; and lack of sound managerial and organizational ability required for successful project implementation and general maintenance of a sound business enterprise.

In some African countries, programmes have been initiated by the Governments to improve upon the capacities and performance of local contractors. For example, in some countries foreign construction companies are required to enter into partnership with local counterparts before they can be registered to operate in the countries. This policy has assisted greatly in the transfer of modern technologies to the local entrepreneurs and in building them up so that they can eventually handle, independently, the bulk of construction projects. In some other countries special schemes have been set up to assist local contractors in the preparation of contract documents, planning and organization of construction works, management of labour force, etc. in order to improve on their efficiency and profitability.

A lesson which can be learnt from the high degree of self-reliance achieved by India in the execution of building and construction projects is that with determination, backed by the formulation and implementation of appropriate policies and programmes, African countries can overcome current problems relating to inadequate local construction capacity. The tendency to favour foreign construction companies in the award of contracts should be controlled by governments and programmes for improving the capacity of local entrepreneurs to handle more complex jobs should be planned and implemented.

IV. FOLLOW-UP ACTIONS

At the end of the workshop organized after the study tour of the first team of African experts, the experts made recommendations for the attention of African Governments, the Economic Commission for Africa and other international organizations regarding the measures that should be taken to bring about improvements in the building materials and construction sector in the countries of the African region, giving due attention to the experiences gained by India in this field. These recommendations are presented in Annex I.

It was evident from the reports submitted to the Secretariat of ECA by the participants in the study tour and in-plant training programmes that the activities undertaken in India had constituted a successful exercise in technical co-operation among developing countries (TCDC) and that ECA should continue to promote such TCDC activities. The experts, however, regretted the inability of ECA to sponsor experts from a greater number of African countries in the training programmes due to financial constraints. They therefore called upon ECA to take the necessary measures to ensure that the experiences gained in India by the experts were disseminated widely in the African countries through the organization of regional/subregional/national seminars and also through the publication of technical documents. ECA was also requested to organize other study tours on various aspects of the building materials and construction sector in African countries, as well as in countries outside the region, for African experts.

Another practical follow-up action which ECA was called upon by the African experts to undertake is the establishment of pilot-cum-demonstration plants, in collaboration with interested African countries, for the production of selected building materials (for example, lime, lime-pozzolana, cement on small scale, roofing sheets from agricultural wastes, etc.) based on simple technologies that have been developed in India. Such centres would not only provide opportunities for demonstrating the viability of the new technologies, but would also be used for training technicians from other countries and serve as instruments for transferring the technologies to African countries. This action is considered very important because the technologies are new to most African countries, even though the raw materials are available locally.

The development of new technologies and their effective application in the building materials industry is another important area where the intervention of ECA is considered vital for the industry's development in the African region. In this connexion, ECA has been requested to promote and support the establishment of working groups/committees for the development, standardization and popularization of new technologies in Africa.

The African Governments themselves have an important role to play in ensuring that maximum use is made, at the national level, of the opportunities for making greater use of indigenous resources for improving the condition and performance of the building materials and construction sector that have been brought into focus by the training programmes organized by ECA in India. In particular, they should give priority attention to the following areas:

(i) The governments should take steps to speedily establish a "National Buildings and Construction Development Cell" (or strengthen an existing mechanism) to assist in the detailed and co-ordinated planning of the building materials and construction sector in respect of innovative policies and programmes and institutional services, taking into account the relevance of India's experiences and availing of India's assistance, if necessary;

(ii) Based on a determination of the aspects of the Indian experiences that could possibly be applied in the countries, the Governments should take steps to obtain further detailed information as may be necessary, either directly from the relevant Indian organizations or through the secretariat of the Economic Commission for Africa. It might also be necessary to sponsor selected national experts for further training and consultations in India with regard to specific technologies or practices which could be considered for adoption or modification to suit local conditions;

(iii) The Governments should speedily undertake detailed investigation, evaluation and documentation of locally available raw materials, where this has not been done already, and promote schemes for developing or processing the raw materials for the production of building materials including the upgrading and optimum utilization of inferior grade materials, secondary species of wood and their wastes, agricultural and industrial wastes, etc.;

(iv) The Governments should draw up a long-term development programme, with the assistance of ECA or donor agencies if necessary, for the establishment of production facilities for specific building materials based on concepts of small and medium-scale production technologies, low investment, maximum use of local materials and local entrepreneurship, as well as the relevant Indian experiences in the field of mini-cement plants, the production of lime, clay-pozzolana, clay bricks and roofing materials, the processing and use of secondary species of wood and utilization of non-conventional sources of energy (solar energy, biogas, wind energy, etc.);

(v) The Governments should seek avenues for establishing operational linkages with other developing countries and international organizations with a view to developing bilateral and multilateral technical co-operation in the field of building materials and construction industries. In this connexion, the possibility of establishing firm co-operation arrangements with India should be investigated and the appropriate actions taken.

V. CO-OPERATION BETWEEN AFRICAN COUNTRIES AND INDIA

The findings of the training programmes organized in India by ECA for African experts point to similarities in the problems that face India and African countries with regard to the development of the building industry to ensure a high degree of self-sufficiency. India has made significant progress in this direction and African countries can derive some lessons from the experiences of that country.

In his opening speech to the workshop on the development of the building materials and construction industries in Africa held in New Delhi in June 1981, the Secretary of the Ministry of Works and Housing of the Government of India expressed the hope that the initiative taken by ECA to organize the workshop would pave the way for future collaboration between India and African countries in tackling the problem of housing and building expeditiously. 8/ He also assured the experts of the willingness of the Government of India to provide technical assistance in specific fields as might be identified by the African experts during the workshop. The representatives of the All India Brick and Tile Manufacturers Federation and the Lime Manufacturers Association of India also declared the willingness of their unions to assist African countries in setting up building materials plants based on technologies developed in India. There are therefore great opportunities for promoting further co-operation between India and African countries in the field of building materials and construction. The modalities for ensuring this co-operation should be defined and implemented.

1. Identification of areas of co-operation

Highly trained technical manpower is an essential ingredient for the development of scientific and technological capability and in view of the long gestation period required, it is important to consider the training of technicians, scientists and engineers as one of the areas of co-operation.

Another important area for co-operation will be in the scientific, technological and industrial fields. In the industrial field for example, there could be co-operation in setting up of building materials industries such as cement, lime, lime-pozzolana, brick and tile, using technologies appropriate to the African situation. Other areas of co-operation could be defined to meet the specific needs of individual countries.

2. Mechanism of co-operation

Broadly, co-operation in the development of manpower may take two forms. African Governments may arrange to recruit skilled manpower from India to train African scientists, engineers and technicians in the countries. They could also arrange with the Government of India to send African scientists, engineers and technicians to India for varying periods of training and refresher courses. Both types of co-operation for manpower development will be needed.

8/ Report on Workshop on the development of the building materials and construction industries in Africa based on Indian experiences, ST/ECA/HUS/3, October 1981.

In the field of science, technology and industry, similar methods can be adopted. Above all, there should be an arrangement for regular exchange of scientific and technical literature. The research and development institutions have an important role to play in this regard. In addition, Indian technologists and industrialists may be required, on consultancy basis, to establish building materials plants using proven Indian technology. Any institutions and organizations whose support the new industries will require may have to be set up through managerial consultancy from India. Industrialists from India may be encouraged to be joint partners to some of the industries that will be set up.

3. The role of ECA and other United Nations Organizations

The United Nations Economic Commission for Africa and other United Nations organizations such as UNCHS (Habitat), UNIDO, UNDP and UNEP have an important role to play in the promotion of co-operation between African countries and India in the building materials and construction sector. The specific areas in which these organizations can provide assistance include the following:

(i) The establishment of operational linkages with various organizations in India with a view to assisting African countries in developing bilateral and multilateral technical co-operation in the field of building materials and construction;

(ii) The establishment of a regional information system with subregional and national linkages, in order to give African countries access to technical information available in other African countries and in countries outside the African region, including India;

(iii) Assistance in mobilizing funds to sponsor African scientists and technical personnel for training courses, including study tours in India;

(iv) Organization of meetings, seminars and workshops on aspects of the building materials and construction industries at the regional, subregional or national level during which Indian experiences could be highlighted and in which experts from India could be invited to participate; and

(v) Promotion of the establishment of joint regional or subregional research centres for the development of the building materials and construction industries in Africa, in collaboration with the relevant institutions in India, as may be necessary.

RECOMMENDATIONS OF WORKSHOP ON DEVELOPMENT OF THE BUILDING MATERIALS AND CONSTRUCTION INDUSTRIES IN AFRICA BASED ON INDIAN EXPERIENCES 1/

In the field of policy, planning and promotion

(i) Each African Government should speedily establish (or strengthen existing mechanism) a "National Building Development Cell" to assist governments in the detailed planning of this sector in respect of innovative policies and programmes and institutional services including development of skills with the assistance of ECA wherever required, taking into account the relevance of India's experiences and availing of India's assistance, if necessary.

In the field of production of building materials

(ii) African Governments should individually or through their economic communities, speedily undertake a detailed investigation, evaluation and documentation of locally available raw materials and promote schemes for developing/processing the raw materials for production of building materials, including the upgradation and optimum utilization of inferior grade materials and secondary species of wood and their wastes.

(iii) African Governments should draw up a long-term development programme, with the assistance of ECA if necessary, for the establishment of production facilities for specific building materials based on concepts of small and medium scale production technologies, low investment, maximum use of local materials and wastes and local entrepreneurship, as well as relevant Indian experiences in the field of mini-cement plants, the production of lime, clay pozzolana, clay bricks, utilization of non-conventional sources of energy (solar energy, biogas, wind energy, etc.).

(iv) In order to popularize the production possibilities referred to above, ECA should assist African Governments and their concerned economic communities in setting up pilot plants/demonstration projects in appropriate locations, as a matter of priority.

(v) Based on the above efforts and experience, African Governments must organize/undertake required pre-feasibility/feasibility studies to lead to the establishment of a network of economically viable plants for production of building materials. ECA's assistance in this regard will be necessary.

In the field of low-cost housing

(vi) African countries should make concerted efforts to achieve low-cost housing, both in urban and rural areas, by improving the design and construction practices, efficient architectural planning, economical use of materials, new and improved construction techniques, better management of construction projects, etc. ECA should be instrumental in promoting developments in these fields.

1/ Report on workshop on the development of the building materials and construction industries in Africa based on Indian experiences, ST/ECA/HUS/7, October 1981.

(vii) To achieve significant results in the above fields, African Governments should earmark specific funds for the implementation of low-cost housing projects.

(viii) To promote low-cost housing, experimental and demonstration housing projects should be undertaken in urban and rural areas, using innovative building techniques, new construction materials, new design concepts, etc. Proper feedback of experiences of such projects should be organized by ECA for effective transfer of technology in the field of low-cost housing in the African countries.

In the field of research and material standardization

(ix) African Governments should undertake a positive programme of promoting building and building materials research with emphasis on the development of appropriate technologies; for this purpose African Governments should strengthen existing material laboratories or set up new research centres according to their needs with emphasis on regional and subregional co-operation as well as co-operation with countries outside the African region.

(x) ECA should promote the establishment of regional/subregional research centres for the development of the building materials and construction industry in Africa and in this context, should assist selected existing national research centres to become focal points for urgent and specific research programmes.

(xi) The research programmes and the programmes for production of building materials should be effectively linked with national housing and construction programmes as well as with measures for the standardization of the building materials and their quality control.

(xii) To facilitate the development of new technologies and their effective application, ECA should promote and support the establishment of working groups/ committees for the development, standardization and popularization of new technologies in Africa.

In the field of information on building materials and building techniques

(xiii) ECA should establish a central information system (Data bank) with subregional and national linkages in order to give African countries access to technical information on the building and building materials industry in the African region and in countries outside the African region.

(xiv) ECA should assist African countries in respect of technical know-how by organizing seminars, workshops and study tours for African experts on various aspects of the sector. The study tours should be organized in African countries themselves besides countries outside the African region. In this connection, ECA is urged to organize a regional seminar as a follow-up to the current study tour and workshop in India.

In the field of skills development

(xv) African Governments should organize specific programmes for manpower training with emphasis on skills upgrading and on-the-job training for artisans, craftsmen and technicians.

In the field of International Co-operation

(xvi) ECA should establish operational linkages with various organizations within and outside the African region with a view to assisting African countries in developing bilateral and multilateral technical co-operation in the field of building materials and construction industries.

INVESTMENT AND LABOUR REQUIREMENTS FOR BRICK PLANTS IN INDIA 1/

	Optimum size of plant - annual capacity (million)	Total investment for production of 1 million bricks (1,000 US$)	Total number of persons employed per 10 million bricks	Remarks
1. Handmade bricks by bulls trench kiln	3-5	10-12	300	Buildings up to three storeys; plastering required
2. Bricks by soft mud machine (NBO)	5	150	200	Buildings up to five storeys; no external plastering required
3. Bricks by semi-mechanized process (CBRI)	5	250	200	Buildings up to five storeys: no external plastering required
4. Bricks by mechanized process	40	250	75	Buildings up to five storeys; no external plastering required

1/ Source: Production and utilization of bricks, roofing tiles and other masonry blocks by A.V.R. Rao. Paper presented at workshop on the development of building materials and construction industries in Africa, New Delhi, June 1981.

CAPITAL INVESTMENT FOR MINI-CEMENT PLANTS 1/

Capacity	50 TPD		100 TPD		150 TPD		200 TPD	
	VSK	RK	VSK	RK	VSK	RK	VSK	RK
Fixed capital (US$ 10,000)	151.13	-	216.65	-	294.12	512.94	387.06	658.82
Working capital (US$ 10,000)	9.77	-	18.24	-	23.53	48.23	29.41	47.06
Total capital (US$ 10,000)	160.90	-	234.89	-	317.65	561.17	416.47	705.88
Investment per annual tonne of installed capacity (US$)	97.5	-	71.2	-	64.2	113.4	63.1	107.0

Note: The cost figures were converted from Indian rupees to US dollars using the exchange rate of US$ 1 = Rupees 8.50.

VSK: Vertical Shaft Kiln
RK: Rotary Kiln

1/ Source: S.K. Chopra - "Cement production in small scale". Paper presented at workshop on the development of building materials and construction industries in Africa. New Delhi, June 1981.

INVESTMENT FOR LIME PLANTS IN INDIA 1/

	A	B	C	D
Capacity, tonnes per day	5	10	20	50
Capacity, tonnes per annum	1,500	3,000	6,000	15,000
Total investment (US dollars)	31,250 to 43,750	62,500 to 100,000	250,000	500,000
Investment per annual tonne (US dollars)	20.8 to 29.2	20.8 to 33.3	41.7	38.3
Fuel used	coal	coal	coal	coal

1/ Data from "Production and utilization of lime and pozzolana in India" by A.V.R. Rao, New Delhi, June 1981. The 20 and 50 tonne per day plants have mechanical hydrators. The costs include working capital.

SOME INDIAN ORGANIZATIONS DEALING WITH ASPECTS OF THE DEVELOPMENT OF THE BUILDING INDUSTRY

1. Central Building Research Institute (CBRI)
   Roorkee (U.P.)

2. Cement Research Institute of India (CRI)
   M10 South Extension II Ring Road
   New Delhi 110049

3. Forest Research Institute (FRI)
   P.O.New Forest, Dehradun 248 006

4. Indian Plywood Industries Research Institute (IPIRI)
   Tumkur Road, Bangalore - 560 022

5. Structural Engineering Research Centre (SERC)
   Roorkee (U.P) - 247 672

6. Structural Engineering Research Centre (SERC)
   CSIR Campus, Madras 600 020

7. National Research Development Corporation (NRDC)
   20-22 Zamroodpur Community Centre
   Kailash Colony Extension
   New Delhi - 110048

8. National Buildings Organization (NBO)
   "G" Wing, Nirman Bhavan
   New Delhi - 110011

9. Housing and Urban Development Corporation (HUDCO)
   12A Jam Nagar House
   New Delhi - 11

10. Khadi and Village Industries Commission (KVIC)
    Bombay

11. All India Brick and Tile Manufacturers Federation
    1-E/21, Jhandewalan Extension
    New Delhi - 110055

12. Lime Manufacturers Association of India
    10 Alipur Road, New Delhi 110054